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Original Article

A Study on the Improvement of a Spatial Sound Quality using Stereo Techniques of Multi-layered Structures for Sound Effects in Virtual Spaces

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Abstract *- The general metaverse environment builds new environments based on the visual effects of users. These environments did not consider the general acoustics of the surrounding environment, and only the visual effects were considered in this study as acoustic effects. A general user's surrounding sounds and phonetic sounds are comprehensively created and used as a model. These models were created by expanding them into a group model by grouping them with surrounding users and environments. These groups were gathered to form a collective group, and the acoustic environment was given as a weight between the users in the group. Various characteristics were used to make acoustic considerations. This thesis conducted research focusing on obtaining effects on users' sense of immersion by using this acoustic approach and applying it to the virtual space or the space of the metaverse.*

Keywords *- Virtual space acoustic environment, Metaverse, Weighted sound effect group, Ambient acoustic environment.*

1. Introduction

Metaverse spaces refer to new virtual worlds that combine technologies such as virtual reality (VR), augmented reality (AR), blockchain, and artificial intelligence. It is a new type of digital world that goes beyond the Internet to provide real-world-like experiences and facilitates interactions and communication between participants. Metaverse is expected to be used in various industries and fields and is already actively used in games, entertainment, education, medical care, and real estate. In this study, Chapter 2 introduces the existing methods and characteristics, and Chapter 3 introduces the proposed method and its characteristics. Finally, in the conclusion, the research results and future research plans are introduced. The general ones in the metaverse are growing fast as they combine popular skills and offer new experiences. It is also a new market in which various companies are participating. As a result, competition is fierce and expected to become more intense with the emergence of new services and technologies. Various types of experiences can be provided, so participants can find the experience that suits them. The advantage of the metaverse is that it can provide new and diverse experiences, and participants can experience impossible things in the real world. It facilitates interaction and communication between participants, providing impossible experiences in the real world. It can be applied to industries such as games, entertainment, education, medical care, and real estate in various fields, and new business models can emerge accordingly. The downside of the metaverse is that it is a new digital world that combines new technologies, so there are technical limitations and limitations. It can limit participants' experiences, and it may take time and money to overcome the limitations of existing technologies until new technologies emerge. Since these digital worlds have multiple participants, security issues will likely arise. A security system is required because problems such as theft of digital assets and leakage of personal information may occur.

Because it is a new concept, public awareness and understanding may be lacking. Participants need information and education about the metaverse, which takes time and money. Currently, the metaverse is dominated by several large corporations. As a result, problems with the centralization of the metaverse may arise, and the development of decentralization technology is required. Because the metaverse is no different from the real world, social problems like reality can arise. As a result, various problems are likely to occur within the metaverse, and solutions are required. In conclusion, the metaverse is a new market that offers new technologies and experiences and is highly likely to be used in various fields. Due to this, there are various problems, such as technical limitations, security problems, recognition problems, centralization problems, and social problems, so it is necessary to develop technologies and methods to solve them.

In this paper, stereo-level approaches were studied as an acoustic approach proposed to overcome the technical

limitations of realization according to the design of virtual space. In Chapter 2, various methods for realism are introduced, and their advantages and disadvantages are identified. In Chapter 3, the proposed stereo-level acoustic approach is introduced. Finally, Chapter 4 introduces the conclusion and future research directions.

2. Existing Method

When developing the metaverse, the most difficult part is explained by dividing it into strengths and weaknesses. As for the advantages, creative ideas and technical skills are required because it provides experiences in dimensions different from the existing virtual world or the real world. This allows experts from various fields to work together to deliver new innovative experiences. Second, metaverse development requires the convergence of various technologies and fields. We create a metaverse world by converging various technologies such as virtual reality (VR), augmented reality (AR), artificial intelligence (AI), and blockchain. In this way, technological development and innovations in various fields can be achieved. On the downside, the first metaverse developments are very expensive. There are various costs, such as hardware, software, and human resources, to build a new world, and financing can be difficult. Second, there are issues such as security and privacy. Since various users access and exchange information, there is a high possibility of security problems such as hacking. You need to have a plan in place to respond to this. In other words, various laws and regulations in the new world are prepared to respond to problems when they occur. Third, there are various regulations and legal issues. Various issues, such as legal regulations in various countries, intellectual property issues, and terms of use, may arise, and legal responses are needed to resolve them. Developing a metaverse world with these advantages and disadvantages in mind is a very difficult and complex task, but if successful, it could be a way to create a world with tremendous destructive power that opens up new industrial fields. Among these problems, this study will examine the acoustic problem, which is the technical part, by dividing it into two major parts.

First, acoustic problems in the metaverse can arise from conflicting or mixed sound information among users. Since there are various environments and objects in the metaverse, the acoustic information of these environments can collide or be mixed. This may affect the user's auditory experience. Second, acoustic problems in metaverses are spatial limitations of sound due to limitations of perception. In the metaverse, sound information plays an important role for users to feel as if they are in a virtual reality space. However, the range of space in which the user is located may be limited due to limitations in perception. A space in which a user can recognize acoustic information may be limited. These acoustical issues need to be considered during the metaverse development process, and advanced audio and 3D audio technologies are required to solve them. Therefore, in this study, among these problems, research was conducted for the virtualization of the acoustic part that can be heard in different real worlds.

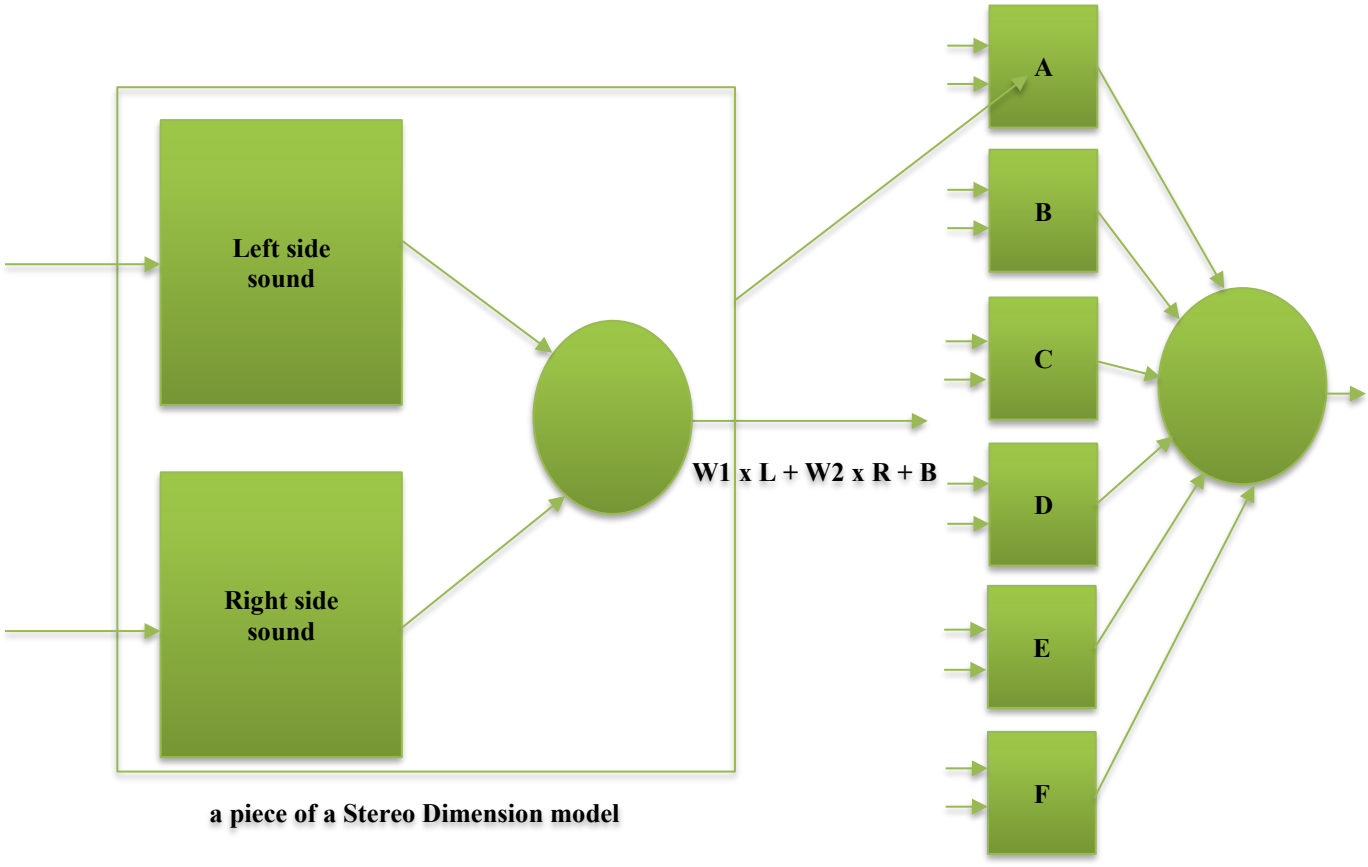

Fig. 1 An example of this stereo model configuration for a user and multi-layer configurations

3. Proposed Stereo Method of Multi-Layer Structures

This study is to find improvements by considering acoustic problems among the problems that appear in virtual space. Most of the acoustic problems are mainly improved by considering the quality of sound quality or the characteristics of the space in real space. These days, spatial improvements for high sound quality or various spaces necessary for sound quality delivery are mainly being developed. The interior space is being constructed to improve the acoustic quality. However, on a non-face-to-face basis, most people want to feel the sense of space in a direct space or the magnificence felt in the field rather than complaining about the sound quality. Dissatisfaction with the sudden non-face-to-face appears here and there, and most of these complaints do not satisfy consumers, so virtual spaces have been developed here and there. The reality is that users are hearing unsatisfactory quality because the metaverse is also transmitted without improvement in other sound quality considerations to the virtual space developed in this way.

In general, a non-face-to-face environment using a network consists of video and audio. This is because it can solve the user's frustration with the conversation with two characteristics. Here, the virtual environments should give visual effects to the buildings or structures in the video so that there is no difficulty in meeting or meeting in the same space. In this case, most of the structures are composed of familiar structures in real environments. Here, the acoustic elements accounted for less weight than the visual effects. Therefore, in this study, due to the fact that it suppresses the sense of realism felt in the virtual space and the stuffiness that appears in this respect, the study was focused on the acoustic part. In this study, first of all, the voice and ambient sounds provided to users are composed of one-channel sound. Here, the ambient sounds of the user are processed in such a way that weight values are given less when the user does not speak, and weight values are increased when the user speaks. The weighted sounds created this way were processed as a model and configured, as shown in Figure 1. Each of these models represents the sound of several users and receives inputs by combining them. These are processed as more close ambient sounds in the same environment by applying a method of grouping users in the same environment. The grouped sounds are configured as one group sound and transmitted. Groups applied in this way do not have correlations with each other, but in the same group, it is possible to obtain the effect of somewhat disappearing distance. Expression is a formalization of this. One small model represents the sound of each user, and the sum of the models replaces the ambient sound representing the environment of the surrounding groups.

$$Tn = An + Bn + Cn + \dots Nn \tag{1}$$

$$MTn = aT1 + \beta T2 + \sigma T3 + \dots + \rho Tn \tag{2}$$

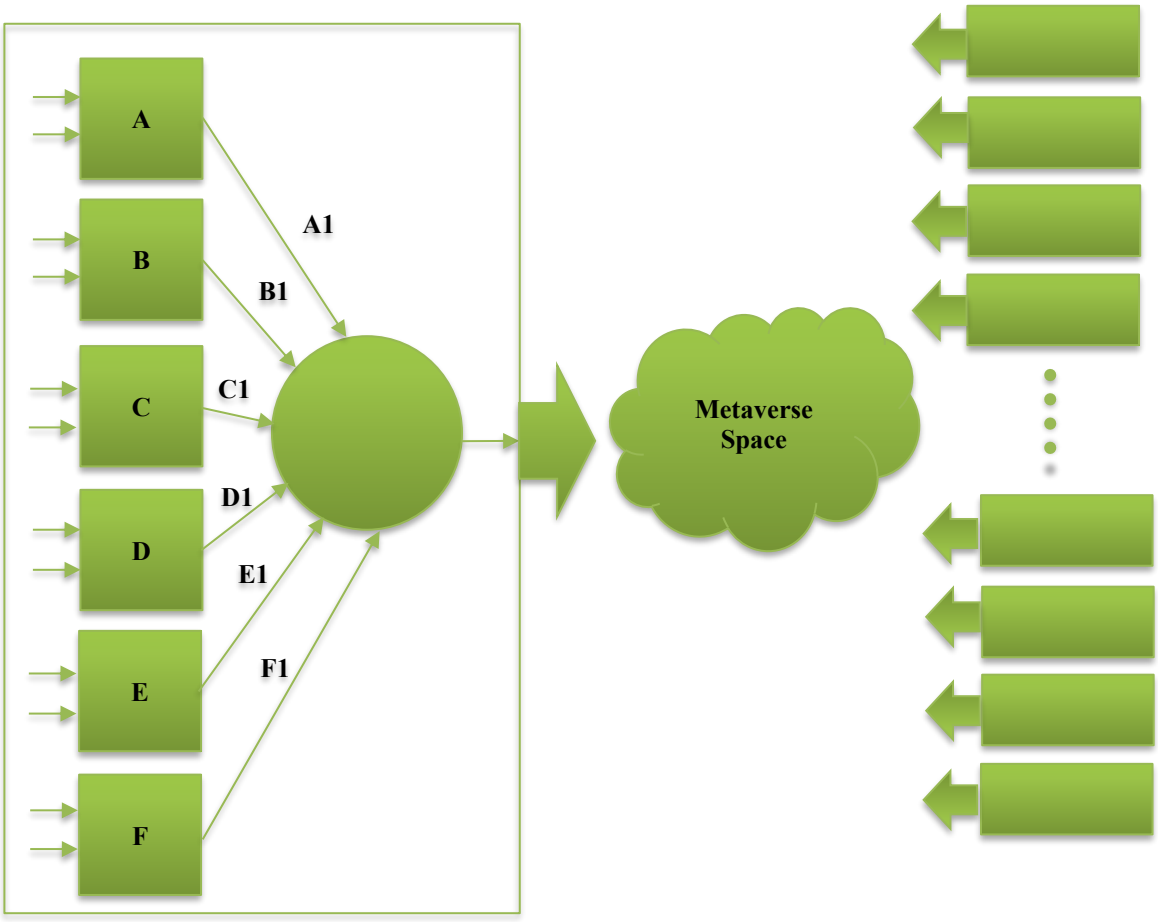

Fig. 2 Configurations in the metaverse through multi-layered networks

Here, A and B represent respective users, and α and β represent weights given to the users. Users who receive each stereo input receive ambient sounds and their own voices according to different environments. Here, it is shown in Equation 1 that modularization is performed by adding each user and surrounding sounds. Here, the sounds unified in the stereo sound are used as an output by adding weights. The use of weights is given to use in proportion to ambient sounds. This is to prevent sounds between users from being inaudible due to surrounding sounds because the intensities of sounds between users are different. Equation 2 shows an example of applying these weights.

Figure 2 shows the overall organization of these groups. Since one group is composed of several models, it can be seen that one model represents the ambient sound of various users. Here, one group can be reconstructed into a multi-layered group so that the sound of the collective group can be applied. In this study, a test was conducted using two groups, and an equation giving weight to the group was solved in case of asymmetry to the surrounding sound. In the end, the method of constructing one model was applied to the group, and when there was no group used by the user in the group, the weight was less, and the method of giving more weight to the group with the user was applied as it is. The sounds of each group tend to be noisy with somewhat complex configurations as the number of users increases, but the proper arrangement of weights is the key to the study. It is possible to increase the realism of the virtual space and the visual effect by allowing the user to hear sounds encountered in various environments rather than hearing the surrounding sounds of the other user using stereo sounds.

4. Conclusion

Various changes in the virtual space gave users a sense of reality by giving visual changes. In these studies, when the changes in structures are different, the part where users adapt becomes a problem, so the biggest problem is that they cannot stay in the space for a long time and feel stuffy. While efforts have been made to solve this problem by expanding non-face-to-face specificity to virtual space, various problems have begun to appear. Therefore, this study conducted research on the acoustic part, which has not been dealt with so far, rather than the visual part. It is based on the fact that the acoustic couple differs depending on the user's environment. If only the visual part is the same, a sense of heterogeneity appears. Therefore, a single model structure was created to put each user's surrounding sounds and voices into the virtual space as much as possible. This single model is a structure with weights, which adjusts the environmental sound according to the value of the weights. Several of these models were collected and grouped, which also applied group weight values to control ambient sounds for the group. This is so that the ambient sounds generated by the group have minimal impact on other users. In conclusion, the sound effects of these multi-layered structures can be applied in various virtual spaces and have an effect that further doubles the realism of the virtual space between users. In the future, this study will further develop to minimize the sense of heterogeneity felt in virtual space and maximize the feeling of participating together in reality.

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